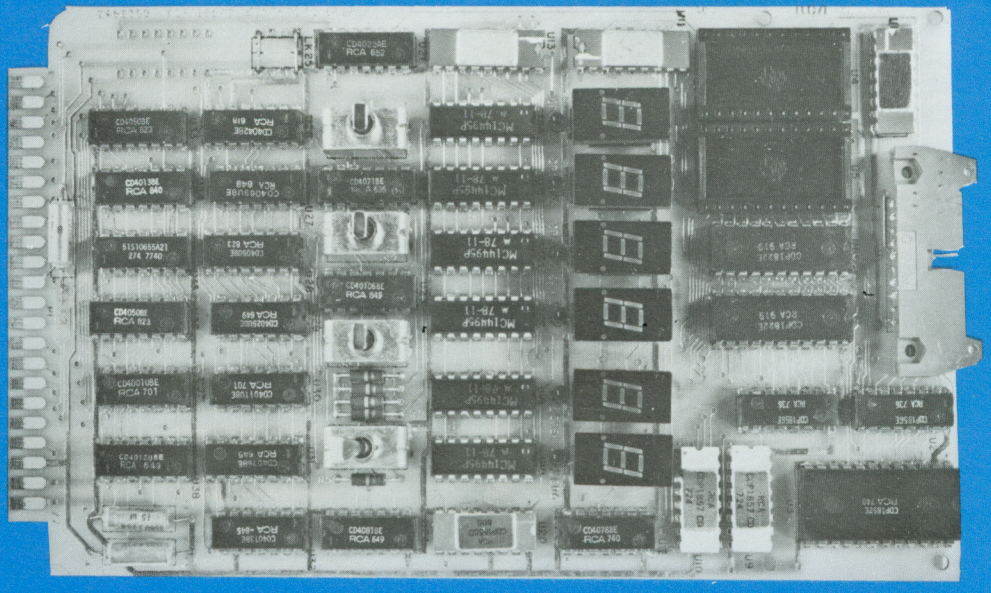
RCA Solid State

RCA COSMAC Microboard Control and Display Module

CDP18S640



RCA COSMAC Microboard
Milliwatt Computer Systems

RCA COSMAC Microboard Control and Display Module

CDP18S640

The RCA COSMAC Microboard Control and Display Module CDP18S640 provides the operating controls and the display for any Microboard system using the CDP18S601 or CDP18S603 Microboard Computer. It includes four switches (RESET, RUN U, RUN P, and STEP/CONT); six hexadecimal display digits; six LED status indicators; a 1-kilobyte Utility ROM UT60 in socket U4; an additional socket that may be used for either 1 kilobyte of mask-programmed ROM (CDP1834) or 1 kilobyte of EPROM (2758); a one-page (256-byte) RAM for use by either the utility program or the user program; and an interface for Microterminal CDP18S021.

Components

The six-digit hexadecimal **display** utilizes four of the digits for current memory address and two for current data bus content. The six indicator LED's display the status of the following lines: S0, S1 (state code), Q (programmable latched output), WT, CLR (machine mode indicators), and RUN (machine running, not idle, not reset).

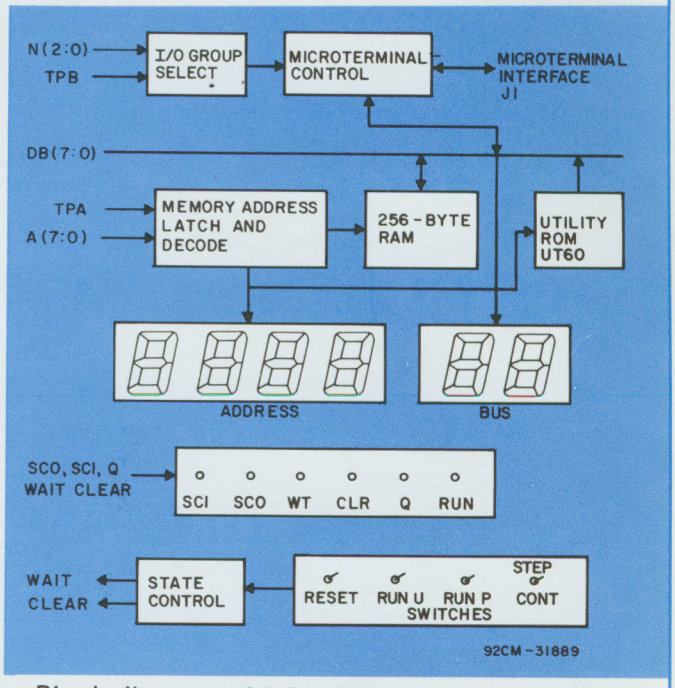
The four **control** switches, labeled RESET, RUN P, RUN U, STEP/CONT, enable the operator to clear the system and hold it in the reset state, to initialize and start the user program at address 0000_{16}, to initialize and start the utility program at address 8000_{16}, or to operate the system in either the single-step mode or in the continuous mode. The STEP/CONT switch may also be used as a manual pause during program operation. The single-step mode permits execution of a single machine cycle for each pressing of the RUN U or RUN P switch. By means of this facility, the operator can observe on the six-digit hexadecimal display the address and data sequences of both the fetch and the execute cycles. A special function of the RUN P switch is continue after idle.

The ROM-based **Utility Program** UT60 operates any standard data terminal (RS232C or 20-milliampere loop), through an associated CDP18S601 or CDP18S603 Microboard computer, to allow the user to examine memory, alter memory, or begin execution at any specified address. These functions are accomplished through a series of commands initiated by a ?, !, or $. The functions include memory insert (!M), memory display (?M), memory move ($M), memory fill ($F), memory substitute (!S), and run program ($P). The move and fill functions can also be called by user programs.

The Utility Program includes read and type routines which provide communication with the user terminal. Once the system has been reset, the user can either press RUN P to begin program execution at location 0000_{16} or press RUN U to begin execution of the Utility Program at location 8000_{16}. After pressing RUN U, the user enters either a CR (carriage return) or LF (line feed). A (CR) will establish full-duplex operation and an (LF) half-duplex operation and, at the same time, calculate the time constant to match the baud rate of the data terminal.

Features

- Low-power static CMOS
- High noise immunity
- Small size (4.5 × 7.5 inches)
- Operable from single 5-V supply
- Interface for Microterminal CDP18S021
- Member of extensive Microboard family
- Uses Microboard Universal Backplane
- Provides control and display for any Microboard system
- Four control switches: RESET, RUN PROGRAM, RUN UTILITY, STEP/CONTINUOUS
- Six hexadecimal display digits
- Six LED status displays
- One-page (256-byte) RAM for either utility or user programs
- Utility ROM on board (UT60)
- Two ROM sockets
- 0° to 70°C temperature range



Block diagram of RCA COSMAC Microboard Control and Display Module CDP18S640.

The Utility Program also includes user-callable routines which help to simplify user programming. These routines provide register initialization, variable delays, text output, and subroutine call and return.

Some debugging capability is provided by a register-save operation. After RESET and RUN U are pressed, the contents of the CPU registers are saved in RAM beginning at location $8C00_{16}$. The contents of R0, R1, and R4.1 are destroyed, however, by the process. The CPU register contents can be examined by displaying memory (?M) beginning at $8C00_{16}$ for 20_{16} bytes.

When the Utility Program is ready to accept commands, it types out an asterisk (*) as a user prompt.

Specifications

Control Switches

RESET—Clears system and latches it in reset state.

RUN P—After RESET, initializes system and starts program execution at 0000_{16}. Continues program execution after idle.

RUN U—After RESET, initializes system and starts UT60 execution at 8000_{16}.

STEP/CONT—In step position, allows execution of a single machine cycle upon depression of RUN P. May be used as manual pause during program execution.

Displays

4 hex digits for address
2 hex digits for data
6 discrete LED's for status:
S0, S1 = State code
Q = Programmable latched output
WT, CLR = Machine mode indicators
RUN = Machine running, not at idle, not reset

Memory Capacity

RAM—256 bytes

ROM—1 kilobyte preprogrammed with Utility Program UT60
—1 empty socket for an additional 1-kilobyte ROM (2758 or CDP1834) at address 8400 through 87FF.

Operating Temperature Range

0° to 70°C

Dimensions

4.5 inches × 7.5 inches (114.3 × 190.5 mm)
Board pitch 0.5 inch (12.7 mm) minimum

Connectors

System interface: edge fingers, 44 pins (dual 22) on 0.156-inch centers

Microterminal interface: connector, 20 pins

Power Requirements

+5 volts at 350 milliamperes, typical operating

Terminal Baud Rates

CDP18S640 (UT60) works with 110, 300, or 1200 baud. Software detects baud rate of terminal and generates a matching rate.

Installation in Microboard System

The CDP18S640 Control and Display module may be installed in any Microboard system incorporating the CDP18S601 or CDP18S603 Microboard Computer or equivalent. Signals transmitted through the Microboard Universal Backplane are used to gain control of the CPU mode and to extract information for the display. Table I provides a list of the pins and the signals for the Universal Backplane Connector (P1). The signals marked with an asterisk (*) are those used on the CDP18S640.

The utility program, UT60, operates on the basis that there is a data terminal interface utilizing the Q output and EF4 input, such as that provided on the CDP18S601 and CDP18S603. If UART operation is

Table I - Pin Terminals and Signals for the RCA COSMAC Universal Backplane Connector (P1)

Pin	Signal		Pin	Signal	
A	TPA-P	*	1	DMAI-N	
B	TPB-P	*	2	DMAO-N	*
C	DB0-P	*	3	RNU-P	*
D	DB1-P	*	4	INT-N	
E	DB2-P	*	5	MRD-N	*
F	DB3-P	*	6	Q-P	*
H	DB4-P	*	7	SC0-P	*
J	DB5-P	*	8	SC1-P	*
K	DB6-P	*	9	CLEAR-N	*
L	DB7-P	*	10	WAIT-N	*
M	A0-P	*	11	−5 V/−15 V	
N	A1-P	*	12	SPARE	
P	A2-P	*	13	CLOCK OUT	
R	A3-P	*	14	N0-P	*
S	A4-P	*	15	N1-P	*
T	A5-P	*	16	N2-P	*
U	A6-P	*	17	EF1-N	
V	A7-P	*	18	EF2-N	
W	MWR-N	*	19	EF3-N	*
X	EF4-N		20	+12 V/+15 V	
Y	+5 V	*	21	+5 V	*
Z	GND	*	22	GND	*

*Signals used on RCA COSMAC Microboard Control and Display Module CDP18S640.

desired, refer to the technical literature for the CDP18S640V1 Control and Display Module, CDP18S602 Microboard Computer, and CDP18S641 UART Interface.

The CDP18S640 should be installed in the end slot of the card nest, such as the CDP18S675 5-card chassis, so that physical and visual access is provided for the four control switches and the digital and status displays.

Manual Operations

RESET Switch. Depression of this momentary switch (S1) causes the assertion of the CLEAR input to the CPU and the removal of the WAIT input, if any. This condition is stored and the system remains in the CLEAR mode until further switch action is made. On the LED status display the CLR (clear) indicator (CR4) is lit and the WT (wait) indicator (CR3) is dark.

RUN P Switch. Depression of this momentary RUN PROGRAM switch (S3) causes the removal of the CLEAR mode, if present. Following a CLEAR mode, RUN P starts execution of the program stored at memory location 0000_{16} after the CPU has executed the initialization cycle. If the STEP/CONT switch is in the STEP position, only one machine cycle will be executed.

If the program reaches an IDLE instruction, it will cycle in continuous S1 states. The RUN P switch may be used to "bump" the system past the IDLE and continue processing. This operation, however, results in the incrementing of register R0.

The RUN P switch affects the RUN, WT, and CLR LED displays. Depression of the RUN P switch will light the RUN indicator (CR6). It will stay lit until an IDLE is encountered or the RESET switch is depressed. The WT and CLR indicators go dark upon depression of RUN P, but WT will light again if the STEP/CONT switch is set in the STEP position.

RUN U Switch. Depression of this momentary RUN UTILITY switch (S2) performs the same functions as the RUN P switch, with an additional function. Depressing RUN U asserts the RNU signal on the Microboard Universal Backplane (Pin 3), resulting in start of execution at memory address 8000_{16}, the location of the utility program UT60.

STEP/CONT Switch. The STEP/CONTINUOUS switch is a toggle switch (S4). When this switch is in the CONT position, operation is continuous at machine speed. When the switch is in the STEP position, each depression of RUN P or RUN U causes execution of one machine cycle. The system stops between TPA and TPB so that the ADDRESS and DATA buses are stable and their contents may be observed in the six hexadecimal display modules. The STEP/CONT switch also affects the state code indicators SC0 and SC1, WT, CLR, and RUN. The WT indicator will be lighted when the system is in the STEP mode even though it is off during the execution of one machine cycle. The CLR indicator will remain dark unless the RESET switch is depressed. The RUN indicator is lighted as soon as a RUN switch is depressed and stays lighted until either an IDLE instruction is encountered or RESET is depressed. The SC0 and SC1 indicators (CR2 and CR1, respectively) tell the state of the CPU. When both are dark, the CPU is in the Fetch state. When SC0 is lighted and SC1 is dark, the CPU is in the Execute state. Thus, stepping through a program, one observes in the Fetch cycle the address of the program step about to be executed and the instruction code on the BUS. Then, in the Execute cycle, one observes the data transaction on the BUS and the memory address to or from which data is transferred. Not all Execute cycles transfer data to or from memory, but most do. Refer to the CPU technical literature for the operation format for each instruction.

The DMA state is indicated when SC0 is dark and SC1 is lighted. The data transaction on the BUS and the memory address may also be observed as described above.

Hexadecimal Displays. The seven-segment hexadecimal LED displays show the current address and data. The high-order address is latched and the low-order address is displayed directly from the bus, so that the full 16-bit memory address may be viewed. The data bus information is displayed directly. Because the STEP mode stops between TPA and TPB, a valid 16-bit address and an 8-bit data byte are displayed for each machine cycle.

Because hexadecimal digits B and D do not map into seven segments uniquely, lower case is used for these symbols. Note that the digit six is displayed as 6, digit B is displayed as b, and digit D is displayed as d.

Operations With IDLE. It is often useful to insert IDLE instructions in a program so that one may stop and check for proper operation before continuing. The IDLE condition is observed when the RUN and CLR indicators are both dark. SC0 will be lighted and SC1 dark indicating the S1 or Fetch state. At this point, the operator chooses one of two techniques for analysis. Pressing RESET and then RUN U returns control to UT60, which is then used to examine register and memory content at the point where IDLE was inserted in the program. Alternatively, pressing RUN P only causes the program to continue past the IDLE.

The mechanization of this restart-from-IDLE feature creates the need for caution regarding the Program Counter assignment. After IDLE is detected, depressing RUN P results in a DMA out request. This request breaks out of the IDLE for the DMA cycle and is

followed by a fetch of the next instruction. If P = 0, R0 is the Program Counter as well as the DMA pointer. The DMA cycle will increment R0, causing a jump over the instruction following the IDLE. In fact, because of capacitive delays, two DMA cycles may occur, resulting in a jump over two instruction locations. Therefore, when R0 is used as the Program Counter, the IDLE should be followed by the insertion of two NO-OP instructions.

It is better to assign P = 3 or greater, so that the DMA pointer, R0, is free. In this case, only an IDLE need be inserted where a break is desired.

The STEP mode may be used concurrently with the IDLE and continue operation. The first DMA after RUN P is pressed will not be seen, but any subsequent DMA will be stepped through the same as any other machine cycle.

Table II - Microterminal CDP18S021 Connections on Microboard Control and Display Module CDP18S640 (J1)

Pin	Signal	Pin	Signal
1	RUN U-N0	2	CLEAR-N0
3	RUN P-N0	4	STEP-N0
5	V_{LED}	6	DB0-P
7	V_{CC}	8	DB1-P
9	TEF3-N	10	DB2-P
11	IO4-P	12	DB3-P
13	IO3-P	14	DB4-P
15	MRD-N	16	DB5-P
17	TPB-P2	18	DB6-P
19	GND	20	DB7-P

Using The Microterminal

Connector J1 and associated logic are provided on the CDP18S640 for the attachment of the COSMAC Microterminal CDP18S021. Because a special utility program, UT5, is provided with the Microterminal, the UT60 ROM in socket location U4, should be replaced with the UT5 ROM. The Microterminal cable connector should be inserted into J1 and the power turned on. Table II provides a list of the pins and the signals for the 20-pin Microterminal connector J1. The four switches on the CDP18S640 are duplicated on the Microterminal keyboard, and either set may be used. The Microterminal display, because it is software refreshed, will not operate in STEP mode, but the Control and Display board operates as usual.

For a detailed description of the Microterminal and its operation, refer to the **Instruction Manual for the RCA COSMAC Microterminal**, MPM-212.

Utility Program UT60

The Utility Program UT60 provided with the CDP18S640 is designed to examine memory, alter memory, and begin program execution at a specified location. These functions are accomplished through a series of commands initiated by a (?), (!), or ($). The functions described include memory insert (!M), memory display (?M), memory move ($M), memory fill ($F), memory substitute (!S), and run program ($P). The move and fill functions can also be called by user programs.

The UT60 includes read and type routines that provide communication with the user terminal. A "software UART" is provided that uses the Q and EF4 lines for output and input, respectively. The timing constant and duplex mode are determined when the utilities are entered from reset. Once the system has been RESET, the user can either press RUN P to begin program execution at location 0000_{16}, or press RUN U to begin execution of UT60 at location 8000_{16}. After pressing RUN U, the user enters either a CR (carriage return) or LF (line feed). A (CR) will establish full-duplex operation and a (LF) half-duplex operation and, at the same time, calculate the time constant to match the baud rate of the data terminal. Acceptable baud rates are 110, 300, or 1200.

The UT60 also includes user-callable routines that help to simplify user programming. These routines provide register initialization, variable delays, text output, and subroutine call and return.

Some debugging capability is provided by a register-save operation. After RESET and RUN U are pressed, the contents of the CPU registers are saved in RAM beginning at location $8C00_{16}$. The contents of R0, R1, and R4.1 are lost, however, by the process. The CPU register contents can be examined by displaying memory (see ?M command below) beginning at $8C00_{16}$ for 20_{16} bytes.

When UT60 is ready to accept commands, it types out an asterisk (*) as a user prompt. The commands described below may then be entered. Where addresses are specified, leading zeroes are assumed; and if more than four digits are entered, only the last four are retained. In all cases, a command is terminated by a carriage return (CR). If a syntactical error is detected during the entry of a command, UT60 will respond with a (?) and re-prompt the user with an asterisk (*).

RCA COSMAC Microboard Control and Display Module

CDP18S640

UT60 Commands

?M Commands

Name: Memory Display

Purpose: To allow a specified area of memory to be displayed on the user terminal.

Format: ?M(START ADDR)(OPTION)(CR)

Action: The contents of memory, beginning at the specified (START ADDR) will be transmitted to the user terminal. (OPTION) allows the transmission of either a specific number of bytes preceded by a space or an inclusive address range preceded by a hyphen. If the option is not specified, a default value of 1 byte results

Examples: ?M2F8 8(CR)

?M2F8-02FF(CR)

Both of these examples produce the same output.

!M Commands

Name: Memory Insert

Purpose: To alter the contents of memory beginning at the specified address.

Format: !M (START ADDR)(SPACE) (DATA)[(CONT)](CR)

Action: A memory location is accessed at the specified (START ADDR). The (DATA) required is one byte specified by two hex digits. The (CONT) option allows data to be continued onto the next line on the terminal with or without changing the current memory address. A (COMMA) will not change the address and after the user inserts (CR)(LF), additional data may be entered. If a (SEMICOLON) is entered and after a user-inserted (CR)(LF), a new address is anticipated. The semicolon allows non-contiguous memory to be loaded with a single insert command. The command may be terminated at any point by the entry of a (CR) not preceded by a (COMMA) or (SEMICOLON).

Examples: !M02F8 7100F840B0F88CB1(CR)

!M02F8 7100F840,(CR)(LF)
B0F8,(CR)(LF)
8CB1(CR)

!M02F8 7100F840B0;(CR)(LF)
03B6 94FB903A0F(CR)

The first and second examples give identical results. The second provides improved readability at the data terminal output. The third example enters data into two memory areas, starting at 02F8 and 03B6.

$M Commands

Name: Memory Move

Purpose: To move a block of data from one area of memory to another area.

Format: $M(SOURCE ADDR)(OPTION) (SPACE)(DEST ADDR)(CR)

Action: Data is copied from memory location beginning at the (SOURCE ADDR) into locations specified by the (DEST ADDR). (OPTION) allows the transfer of either a specific number of bytes preceded by a space or an inclusive address range preceded by a hyphen. There is no restriction on the direction of the move and the areas may overlap.

Examples: $M02F8 8 03F8(CR)

$M02F8-02FF 03F8(CR)

$M03B0-03BF 02B0(CR)

$M03B0-03BF 03B2(CR)

$F Commands

Name: Memory Fill

Purpose: To load a defined area of memory with a specified constant.

Format: $F(START ADDR)(OPTION) (SPACE)(DATA)(CR)

Action: The specified (DATA) is loaded into memory beginning at the (START ADDR). (OPTION) allows the loading of either a specific number of bytes preceded by a space or an inclusive address range preceded by a hyphen.

Examples: $F02F8 8 00(CR)

$F02F8-02FF 00(CR)

These examples fill with zeros the eight bytes beginning at location 02F8.

!S Commands

Name: Memory Substitute

Purpose: To display and, if desired, alter the contents of sequential memory locations beginning at the specified address.

Format: !S(START ADDR)(OPTION)(CR)

Action: A memory location is accessed at the specified (START ADDR). Its contents will not be displayed, however, until (OPTIONS) is entered. (OPTIONS) allows two methods of display: (SPACE) or (LF). If (SPACE) is entered, the current data will be displayed on the same line followed by a hyphen. New data may be entered at this point. Only the last byte entered will be written. If no data is entered, the current data will remain unchanged. If another space is entered, the data in the next sequential memory location will be displayed followed by a hyphen. If a (LF) is entered, a (CR)(LF) will result and the next memory address will be printed followed by the current data and a hyphen. New data may be entered as described above. The command can be terminated by a (CR) or continued by the entry of any number of (OPTIONS).

Examples: !S02F8 63-71 00- 0F-C0(CR)
The current data of 63 is changed to 71. The 00 data is retained, and the 0F is changed to C0.

!S02F8 71- 00- C0- 11-82(LF)
02FC 52-AE(LF)
02FD 00-F8 11-40 23-A3(CR)

In this example, the 71, 00, and C0 are retained and the 11 is changed to 82. Each (LF) causes the next address to be typed followed by its data.

$P Commands

Name: Program Run

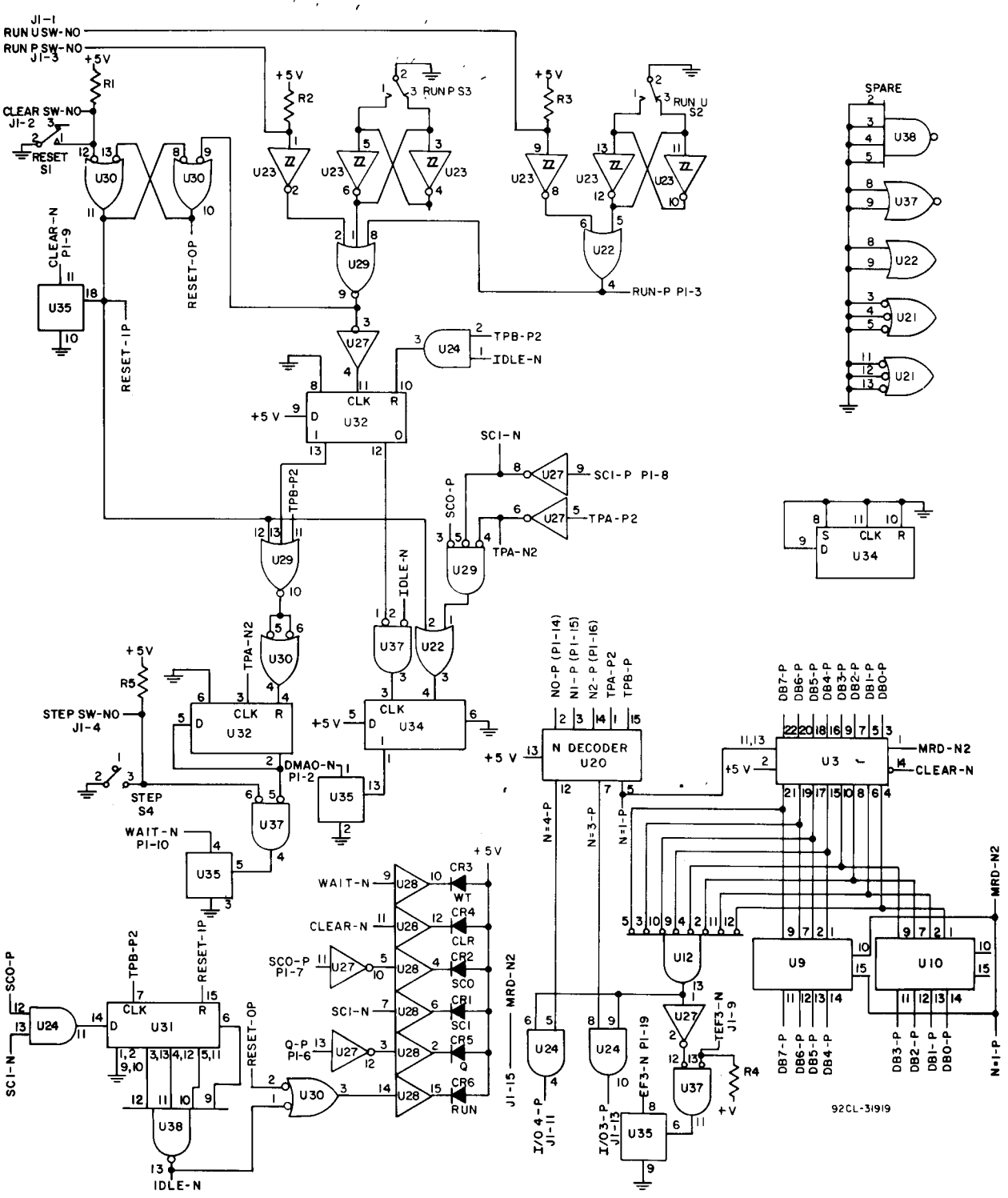
Purpose: To allow a user program to be run beginning at the specified address.

Format: $P[(START ADDR)](CR)

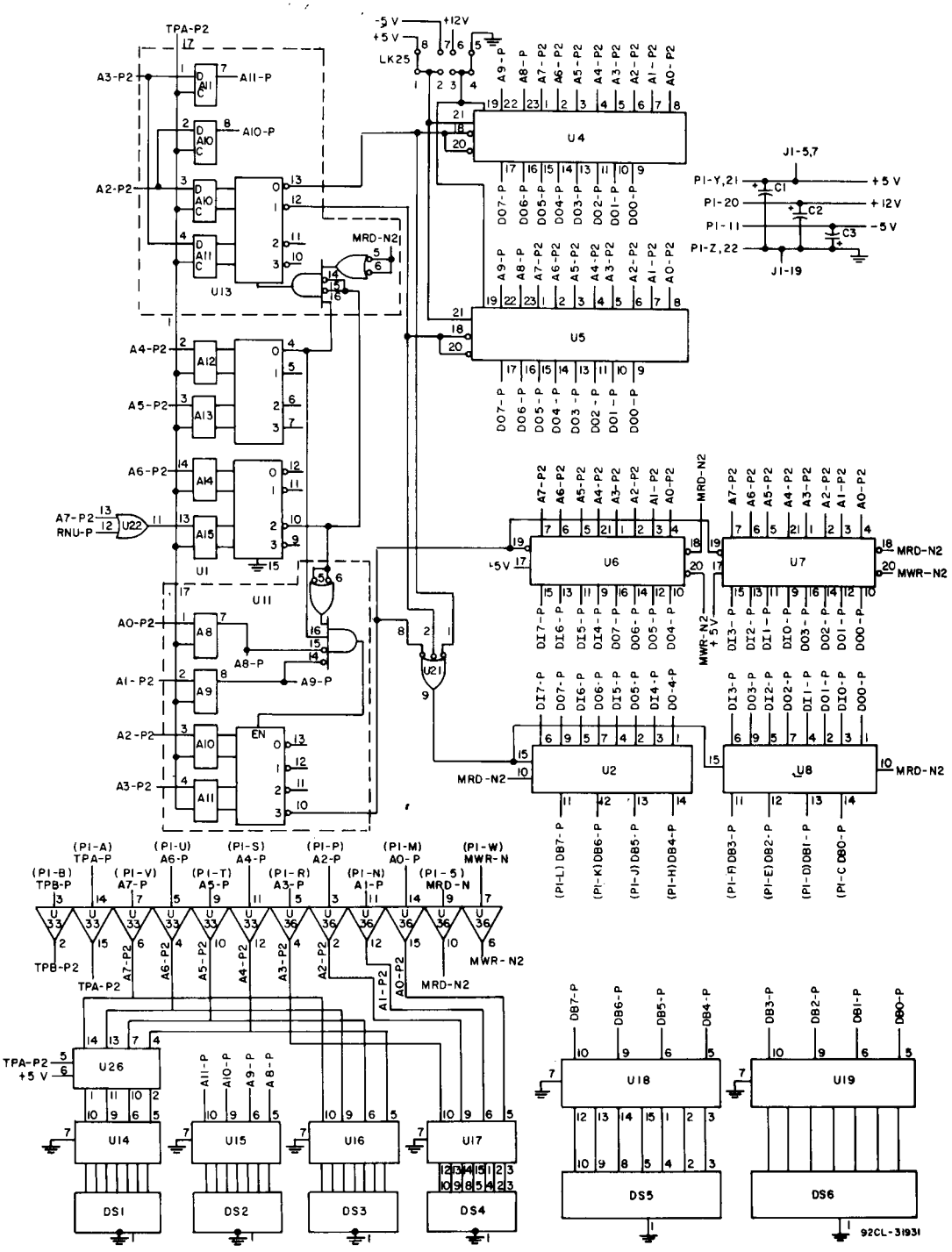
Action: The user program will begin execution at the specified (START ADDR) with P=0 and X=0. If the (START ADDR) is not specified, the default value is 0000_{16}. The interrupt flag is also reset!

RCA COSMAC Microboard Control and Display Module

CDP18S640



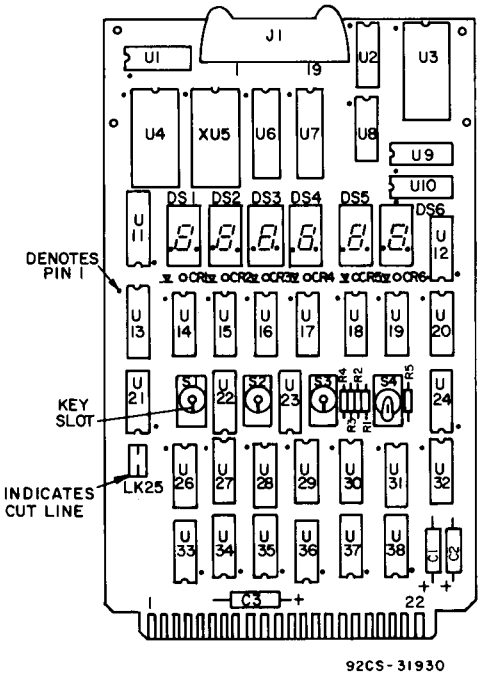
Logic diagram of Microboard Control and Display Module CDP18S640—control and status indicator portion.



Logic diagram of Microboard Control and Display Module CDP18S640—memory and memory display portion.

RCA COSMAC Microboard Control and Display Module

CDP18S640



Layout diagram of RCA COSMAC Microboard Control and Display Module CDP18S640.

Parts List

C1, C2, C3 = 15 μF, 20 V

CR1-CR6 = LED

DS1-DS6 = 7-segment display HP5082-7740
J1 = connector, 20 pin

R1-R5 = 22 kΩ, ¼ W, 5%

S1, S2, S3 = switch, momentary
S4 = switch, SPDT
U1 = CDP1858CE
U2, U8 = CDP1856CE
U3 = CDP1852CE
U4 = Utility ROM UT60
U6, U7 = MWS5101EL-3
U9, U10 = CDP1857CE
U11, U13 = CDP1866CE
U12 = CD4078BE
U14-U19 = MC14495P
U20 = CDP1853CE
U21 = CD4023BE
U22 = CD4071BE
U23 = CD40106BE
U24 = CD4081BE
U26 = CD4042BE
U27 = CD4069BE
U28, U33, U36 = CD4050BE
U29 = CD4025BE
U30 = CD4011BE
U31 = CD4076BE
U32, U34 = CD4013BE
U35 = CD4016BE
U37 = CD4001BE
U38 = CD4012BE
XDS1-XDS6 = DIP socket, 10 pin
XU4, XU5 = IC socket, 24 pin

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